Coiling of basilar tip aneurysms: results in 154 consecutive patients with emphasis on recurrent hemorrhage and retreatment during mid- and long-term follow up

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Abstract

**Purpose:** The purpose of this study is to report mid- and long-term clinical and angiographic results of coiling of basilar tip aneurysms.

**Materials and Methods:** Between January 1995 and August 2006, 154 basilar tip aneurysms were coiled. One hundred and fourteen (74%) had ruptured and 40 (26%) were unruptured. There were 42 men and 112 women with a mean age of 50.5 years (median 50, range 25-73 years). Mean aneurysm size was 11.1 mm (median 10, range 2-30 mm) and 71 (46%) were large or giant. Of 154 aneurysms, 40 (26%) were primarily coiled with a supporting device.

**Results:** Initial occlusion was (near) complete in 144 (94%) and incomplete in 10 aneurysms (6%). Combined procedural mortality and morbidity was 3.8% (6 of 154, 95% CI 1.4-8.3%). Mean clinical follow up of 144 surviving patients was 53 months (range 3-144 months, 637 patient years). Annual incidence rate for recurrent hemorrhage was 0.3% (2 in 637 patient years, 95% CI 0.04-1.1%). During angiographic follow up of mean 34 months (range 6-122 months) in 138 patients (96%), 27 basilar tip aneurysms (17.5%) reopened over time and were additionally coiled. Of these, 11 repeatedly reopened and were repeatedly coiled. Aneurysm size > median 10 mm was the only significant predictor for retreatment at follow up (Odds Ratio 7.0, 95% CI 2.5-19.7).

**Conclusion:** Coiling of basilar tip aneurysms is safe and effective in preventing recurrent hemorrhage. Follow up angiography is mandatory to timely detect reopening, especially in large and giant aneurysms.

Key words: intracranial aneurysms; basilar tip; outcome
Introduction

Since the introduction of detachable coils in the early nineties of the last century, endovascular treatment of basilar tip aneurysms has rapidly replaced surgery for these lesions. Surgical approaches for basilar tip aneurysms are more challenging than for aneurysms at other locations since these aneurysms are deeply located, confined in the narrow interpeduncular fossa in close relation to the midbrain, and surrounded by important perforating arteries. As a consequence, surgery is associated with substantial morbidity (1-3). In several previous studies, safety and effectiveness of coiling of basilar tip aneurysms has been established, also for large aneurysms and for patients in poor clinical grades (4-12). In this study, we want to report our experience in coiling of 154 consecutive patients with basilar tip aneurysms over a 12-year-period, with emphasis on recurrent hemorrhage and retreatment on mid- and long-term follow up.

Materials and Methods

This observational study was compliant with institutional privacy policy. The Institutional Review Board gave exempt status for approval and informed consent.

Patients

Between January 1995 and July 2006, 1839 aneurysms were treated in our institution and 911 of these were selectively occluded with detachable coils. Patients with treated aneurysms were prospectively entered in a database that included various patient- and aneurysm characteristics. Also clinical and angiographic follow up results were prospectively collected and entered in the database at regular intervals. Since the beginning of the study period, endovascular treatment was the therapy of choice for posterior circulation aneurysms and only 7 of 314 posterior circulation aneurysms were treated surgically. One hundred and fifty four aneurysms in 154 consecutive patients were located on the basilar tip and all were coiled. Thus, the frequency of basilar tip aneurysms was 8.4% (154 of 1839) of all treated intracranial aneurysms and 49% (154 of 314) of treated posterior circulation aneurysms. Of 154 basilar tip aneurysms, 114 had ruptured (74%) and 40 had not (26%). Of 40 unruptured aneurysms, 19 were incidentally found on imaging unrelated to presenting symptoms, 18 were additional to another ruptured aneurysm and 3 presented with symptoms of mass effect on the brain stem. There were 42 men and 112 women with a mean age of 50.5 years (median 50, range 25-73 years). Clinical grading according to the Hunt and Hess scale (HH) at the time of treatment in 114 patients with a ruptured basilar tip aneurysm was: HH I-II 68 patients, HH III 25 patients and HH IV-V 21 patients. Timing of treatment after SAH was 0-3 days in 43 patients, between 4 and 14 days in 53 patients and ≥14 days in 18 patients. Mean aneurysm size was 11.1 mm (median 10, range 2-30 mm). There were 83 small aneurysms (≤ 10 mm), 61 large aneurysms (11-24 mm) and 10 giant aneurysms (≥ 25 mm). Of 154 patients, 21 had 25 additional aneurysms at other locations coiled in the same session as for the basilar tip aneurysm.

Coiling Procedure

Coiling of aneurysms was performed on a biplane angiographic unit (Integris BN 3000, Philips Medical Systems, Best, The Netherlands) with the patient under general anaesthesia. Prior to coiling or after placement of the first coil, a bolus of 2500 U heparin was administered intra-arterially followed by drip infusion of 1000 U of heparin per 500 ml infusion fluid during the intervention. Heparin was continued intravenously or subcutaneously for 48 hours after the procedure, followed by 80 mg aspirin daily for 3 months orally. For
procedures with stent placement, patients were preloaded with antiplatelet medication (Clopidogrel 75 mg and Aspirin 80 mg daily). Coiling was performed with Guglielmi Detachable Coils (GDC, Boston Scientific, Fremont, CA) or TruFill DCS/Orbit coils (Cordis, Miami, Fl). Some large aneurysms were coiled with 50 cm long mechanically detachable coils (Detach 18, Cook Inc, Copenhagen, Denmark). The aim of coiling was to obtain a dense packing of the aneurysm, until not one additional coil could be placed.

In the occurrence of aneurysm perforation during coiling, heparin was reversed instantly and coiling was continued until the bleeding stopped. In the occurrence of thromboembolic complications, usually a selective bolus injection of 100,000-250,000 units of urokinase was administered in the involved vessel, in the last four years followed by intravenous infusion of a glycoprotein IIb/IIIa antagonist (tirofiban, Aggrastat, Merck & Co., Inc., Whitehouse Station, NJ, USA) for 24-48 hours (13,14). Initial angiographic results of coiling were classified as (near)complete occlusion and incomplete occlusion. Aneurysm occlusion was determined in consensus during a weekly joint meeting of two neurosurgeons, two neurologists and two neuroradiologists.

Supporting devices
Of 154 basilar tip aneurysms, 40 wide necked aneurysms (26%) were primarily coiled with aid of a supporting device. A wide neck was defined as dome to neck ratio ≤1 or when the origin of one or both posterior cerebral arteries was incorporated in the base of the aneurysm. Twenty-six were primarily coiled with a temporary supporting balloon. During the study period, several occlusion balloons were used for this purpose (15): Balt no I balloon glued on a Magic 1.8 micro catheter (Balt, Montmorency, France), Endeavour non-detachable balloon (Boston Scientific, Fremont, CA), Solstice Balloon Occlusion System (Medtronic MIS, Sunnyvale, CA), Sentry 15 mm balloon (Boston Scientific, Fremont, CA) and HyperForm balloon (EV3, Irvine, CA).

Another 13 wide necked basilar tip aneurysms were coiled with the aid of a TriSpan supporting device (Boston Scientific, Fremont, CA) and one incidental basilar tip aneurysm was coiled after placement of a stent (Neuroform, Boston Scientific, Fremont, CA).

Procedural complications
Procedural complications (aneurysm rupture or thromboembolic) of coiling leading to death or neurological disability at the time of hospital discharge were prospectively recorded in our database during the weekly joint meeting. For comatose patients, thromboembolic complications were considered to have caused neurological deficit if this was either clinically evident or if there were infarctions on subsequent CT scans in the territory of the involved vessel. Procedural rupture in comatose patients who subsequently died was considered as procedural mortality.

Clinical and angiographic follow up
Patients that survived the hospital admission period were scheduled for clinical follow up in the outpatient clinic at 6 weeks and for angiographic follow up at 6 and 18 months. Results of angiographic follow up were classified in the same way as the initial post embolization occlusion. Incomplete occlusion at any point in time was considered an indication for further therapy, unless clinical or anatomical factors dictated otherwise. Clinical follow up was assessed according to the Glasgow Outcome Scale (GOS) at every outpatient clinic visit and at every admission for follow up angiography. Results and consequences of clinical and angiographic follow up were discussed in the weekly joint meeting. When appropriate, during the meeting a decision was made for the need for additional treatment or extended
angiographic or MRA follow up. When additional treatment was performed, the result was evaluated in the weekly meeting and angiographic follow up was scheduled at 6 months. Clinical follow up of patients who refused or were unable to undergo follow up angiography was assessed by contacting the family physician by telephone or in writing at various follow up intervals. Of 154 patients, 85 were included in a previous midterm clinical follow up study conducted in January 2005 (16).

Statistical analysis
For patients that survived the hospital admission period (re)bleeding after coiling was calculated as an incidence rate with corresponding 95% Confidence Intervals (CI) for all aneurysms, for ruptured aneurysms and for unruptured aneurysms. For all 154 basilar tip aneurysms, Odds Ratios for the chance of retreatment at follow up were calculated for the following possible predictors: aneurysm size > median size (10 mm), ruptured aneurysms, use of a supporting device and initial incomplete aneurysm occlusion. Statistical analysis was performed using univariate logistic regression for dependent and multivariate logistic regression for independent risk factors. Mean size of basilar tip aneurysms that reopened over time and were additionally coiled was compared to mean size of aneurysms that were stable at follow up using the t test. Complication rate of first coiling was compared to complication rate of additional coiling using the Chi square test.

Results

Initial angiographic occlusion and complications
Initial angiographic occlusion of 154 basilar tip aneurysms was complete or near complete in 144 (94%) and incomplete in 10 aneurysms (6%). Complications occurred in 6 patients, leading to death in 5 (procedural mortality 5 of 154, 3.2%, 95% CI 1.1-7.4%) and to permanent neurological deficit in one patient (procedural morbidity 1 of 154, 0.6%, 95% CI 0.0-3.5%). Complications leading to mortality consisted of 2 procedural aneurysm ruptures, 2 inadvertent (partial) occlusions and thrombosis of a posterior cerebral artery by malpositioned coils protruding from the neck and one rupture of a superior cerebellar artery branch by the guide wire during positioning of a supporting balloon. One inadvertent posterior cerebral artery occlusion led to permanent morbidity.

Clinical follow up and rebleeding rate
Clinical follow up was available for all 154 patients. Of 40 patients with unruptured basilar tip aneurysms, two died of procedural complications; the remaining 38 patients were neurological intact. Of 114 patients with ruptured basilar tip aneurysms, 8 patients died during hospital admission, 3 after procedural complications and 5 of direct impact of SAH or diffuse vasospasm. Two patients died before the 6 months follow up interval: one patient died of brain abscess after ventricular drainage 3 months after coiling and the other patient died 4 months after incomplete coiling of a 30 mm basilar tip aneurysm of recurrent hemorrhage. GOS score at 6 months follow up for the remaining 112 patients was GOS 1 in 101 patients (90%), GOS 2 in 6 patients (5%) and GOS 3 in 5 patients (5%). Clinical follow up beyond the 6 months interval of all142 surviving patients was mean 53 months (median 49.5, range 3-144 months, 637 patient years). Five patients died of unrelated causes (pneumonia 2, pulmonary embolism 1, disseminated cancer 2). Two other patients, who initially presented with symptoms of mass effect on the brain stem, died of aggravation of symptoms 14 and 24 months after coiling of the basilar tip aneurysm. Besides the patient who died of recurrent hemorrhage 4 months after coiling, one other patient (who had refused...
6 months follow up angiography) experienced a recurrent hemorrhage 12 months after coiling. Annual incidence rate for rebleeding was 0.3 % (2 in 637 patient years 95% CI 0.04-1.1%) for all aneurysms, 0.4% for ruptured aneurysms (2 in 513 patient years, 95% CI 0.05-1.4%) and 0.0% for unruptured aneurysms (0 in 124 patient years, 97.5% CI 0.0-2.4%).

**Angiographic follow up**
Of 144 patients that survived the hospital admission period, 2 died before 6 month follow up interval and 5 patients refused follow angiography. The remaining 137 patients all had angiography at 6 months and the one patient with a recurrent hemorrhage at 12 months had follow up angiogram at the time of rebleeding. Thus, follow up angiography was available in 138 patients for a total of 296 angiograms: 55 patients had one follow up angiogram, 39 patients two, 25 patients three, and 19 patients had 4-8 follow up angiograms. Mean duration of angiographic follow up was 34 months (median 21.5, range 6-122 months).

**Additional treatments and risk factors**
During follow up, 27 basilar tip aneurysms (17.5%) reopened over time and were additionally coiled. Of these 27 aneurysms, 11 repeatedly reopened and were repeatedly coiled: 6 aneurysms were coiled 3 times, 3 aneurysms 4 times, 1 aneurysm 5 times and 1 aneurysm 6 times. Four aneurysms were additionally coiled after placement of a stent (Enterprise, Cordis Neurovascular, Miami Lakes, FL) (fig.1) and four aneurysms were repeatedly coiled with aid of a supporting balloon. All 46 additional coilings were without complications (0%, 97.5% CI 0.0-6.3%). Complication rate of 3.8% of first coiling differed not significantly from complication rate of 0% of additional coiling (Chi square, P = 0.40).

Aneurysm reopening over time was by compaction (fig.1) or migration of coils into intraluminal thrombus in 24 of 27 aneurysms. Mean interval between first and second coiling was 17 months (median 12, range 5-100 months). One small basilar tip aneurysm that was initially completely occluded showed gradual growth over a period of almost 9 years and was finally additionally treated after placement of a stent (fig. 2). Two very large aneurysms that were repeatedly coiled showed late regrowth of the aneurysm at the base near the inflow zone apparent at 89 and 130 months after first coiling (76 and 95 months after last coiling respectively). Altogether, in 154 patients, 225 coil treatments were performed (145 primary coilings, 25 additional aneurysms and 46 repeated coilings).

Mean size of 17.0 mm of 27 basilar tip aneurysms that reopened over time and were additionally coiled was significantly larger than mean size of 9.9 mm of 127 aneurysms that were coiled once (t test, P<0.0001). Of 27 additionally treated aneurysms, 22 were large or giant.

Aneurysm size > median 10 mm was the only significant predictor for retreatment at follow up (Table).

<table>
<thead>
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<th>variable</th>
<th>Odds Ratio</th>
<th>95% Confidence Interval</th>
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</thead>
<tbody>
<tr>
<td>aneurysm size &gt; median size (10 mm)</td>
<td>7.0</td>
<td>2.5-19.7</td>
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<tr>
<td>initial incomplete aneurysm occlusion</td>
<td>3.5</td>
<td>0.9-13.4</td>
</tr>
<tr>
<td>ruptured aneurysm</td>
<td>0.6</td>
<td>0.3-1.6</td>
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<tr>
<td>use of supportive device</td>
<td>2.3</td>
<td>0.97-5.55</td>
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Table  Result of possible predictors for retreatment at follow up for 154 basilar tip aneurysms by multiple univariate logistic regression analysis. Aneurysm size is the only significant predictor for retreatment at follow up.
Discussion

In this study, we found that coiling of basilar tip aneurysms is associated with low morbidity and adequately protects against recurrent or primary hemorrhage. During clinical follow up of all 144 surviving patients and angiographic follow up of 138 patients (96%) up to 12 years, reopening needing additional coiling occurred in 27 aneurysms (17.5%). Of these 27 aneurysms, 11(7%) repeatedly reopened and were repeatedly coiled up to six times. The only significant predictor for reopening and retreatment was large aneurysm size. The rather high retreatment rate of 17.5% is in concordance with other studies concerning basilar tip aneurysms (5,6,11,12) and may be explained by the fact that many basilar tip aneurysms had a wide neck and almost half of the aneurysms were of large or giant size (5). In many patients with large or giant basilar tip aneurysms, coiling may be considered a staged treatment with ongoing follow up. Our findings indicate that basilar tip aneurysms that reopen over time and need to be coiled for a second time, should be followed with angiography or MRA at regular intervals (1-3 years), even when aneurysm occlusion is stable during some years.

Our strict clinical and angiographic follow up strategy with additional treatment when necessary and possible was effective in preventing recurrent hemorrhage in ruptured aneurysms or primary hemorrhage in unruptured aneurysms. Only 2 patients experienced recurrent hemorrhage during follow up and in both patients this probably could have been prevented. In one patient, treated in 1995, failure of electrolytic detachment of coils precluded adequate occlusion of a 30 mm aneurysm. This flaw of early GDC design has been overcome in later years. The other patient refused 6 months follow up angiography and had a recurrent hemorrhage 12 months after coiling. Angiography at that time showed a 50% reopening and enlargement of the aneurysm. It is likely that this reopening would have been present at 6 months, and additional coiling should then have been performed. Our annual incidence of recurrent hemorrhage of 0.3% is lower than reported in other studies. In a meta-analysis by Lozier (11) concerning 221 eligible patients with basilar tip aneurysms annual incidence of recurrent hemorrhage was 0.7%. Henkes (12) reported 11 recurrent hemorrhages after coiling in a series of 317 patients with incomplete angiographic and clinical follow up.

When giant basilar tip aneurysms present with symptoms of mass effect on the brain stem, coiling seems not effective: 2 of 3 patients in this study died of progressive brain stem dysfunction 14 and 24 months after complete occlusion with coils and the other patient died of a procedural complication. Although different treatment strategies for these aneurysms such as single or double vertebral artery occlusion and (bypass) surgery were considered, these therapies were not judged feasible.

Although many wide necked basilar tip aneurysms can be adequately occluded with coils without a supporting device, in 40 of 154 aneurysms (26%) with wide necks that incorporated the ostia of posterior cerebral arteries, primary coiling was performed with aid of a supportive balloon, TriSpan or stent. Also many additional coilings were performed with these devices. Besides procedural rupture, thrombo-embolic occlusion of one or two posterior cerebral arteries by protrusion of coil loops from the neck at the end of the procedure was the most serious complication leading to mortality in three and to morbidity in one patient. Despite formation of an adequate basket over the neck of the aneurysm with the first coils, with insertion of additional coils the coil mesh may slowly expand with protrusion into the parent posterior cerebral arteries resulting in flow restriction and thrombosis. The use of a supporting balloon to protect the neck does not always prevent this complication. A possible solution is placement of a stent. During most part of the study period intracranial stents were not yet available and only one patient was primarily coiled after stent placement. At the end of the study period, a new stent system became available and this stent proved to be easy to handle and valuable in retreating reopened wide necked basilar tip aneurysms (17). However, a
drawback of stent placement in acutely ruptured aneurysms is the required antiplatelet medication. This medication is preferably preloaded several days before stent placement and, since patients may be not responding to both Clopidogrel and Aspirin, verification of response is recommended. To overcome this drawback in patients with acutely ruptured aneurysms, another possible solution to prevent occlusion of the parent artery is leaving the neck wide open at initial treatment followed by stent placement and complete occlusion at a later stage (compaction usually occurs within the first 6 months).

This study is a single centre experience with basilar tip aneurysms treated with coiling. Since the introduction of coiling in our hospital in 1994, no basilar tip aneurysm has been operated anymore. Thus, effectively, all treated basilar tip aneurysms are included in the study. For most part of the study period, our institution has been a tertiary referral centre for endovascular treatment of aneurysms (especially basilar tip aneurysms) for the whole country. For this reason, basilar tip aneurysms may have been overrepresented in our patient population.

**Conclusion**

Coiling of basilar tip aneurysms is safe and effective in preventing recurrent or primary hemorrhage. Follow up angiography is mandatory to timely detect reopening, especially in large and giant aneurysms. Various supporting devices (balloons, stents, TriSpan) are available to coil wide necked basilar tip aneurysms successfully.
References


**Legends to figures**

Figure 1

Wide necked basilar tip aneurysm in a 47-year-old woman reopened by compaction.

A: 3D angiogram shows wide necked basilar tip aneurysm.
B: The aneurysm was near completely occluded with coils.
C: 27 months after coiling reopening with residual aneurysm filling.
D: micro catheter for stent placement navigated over left posterior communicating artery into both posterior cerebral arteries via left internal carotid artery.
E: stent placed horizontally across the aneurysm neck (arrows indicate stent markers).
F: after additional coiling complete occlusion with preserved flow in posterior cerebral arteries.
G: Off-lateral radiograph shows tangential view of stent (arrow) as a scaffold for the coils.

Figure 2

Completely occluded basilar tip aneurysm with gradual growth over almost 9 years in a 54-year-old woman.

A: small ruptured basilar tip aneurysm
B: complete occlusion after coiling.
C, D, E, F: angiographic follow up after 1.5 years, 3 years, 5 years and almost 9 years demonstrates gradual growth and reopening.
G: coil mesh after second coiling with stent placement in the right posterior cerebral artery. Arrows point to stent markers.
H: complete occlusion of the aneurysm after second coiling.
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